

CLAIMS

What is claimed is:

1. A method of making a hydrogenated Group IVA compound, comprising the steps of:
 - a) reacting one or more reducible Group IVA compounds with a metal hydride to form a metal-contaminated, hydrogenated Group IVA compound; and
 - b) washing said metal-contaminated, hydrogenated Group IVA compound with a washing composition comprising an immiscible polar solvent to decontaminate said metal-contaminated, hydrogenated Group IVA compound.
2. The method of Claim 1, wherein said reducible Group IVA compounds comprise one or more compound(s) of the formula A_xX_y , where each A is independently Si or Ge, each X is independently a halogen, x is from 3 to 12, and y is from x to $(2x+2)$.
3. The method of Claim 1, wherein said metal-contaminated, hydrogenated Group IVA compound is washed with the washing composition sufficiently to remove a substantial amount of metal contaminants.
4. The method of Claim 1, wherein said metal hydride comprises a compound of the formula $M^1_aM^2_bH_cR_d$, where M^1 and M^2 are independently first and second metals, each R in said second compound is independently a ligand bound to at least one of M^1 and M^2 by a covalent, ionic or coordination bond, at least one of a and b is at least 1, c is at least 1, and d is 0 or any integer up to one less than the number of ligand binding sites available on the (a + b) instances of M^1 and M^2 .
5. The method of Claim 4, wherein said washing step is conducted sufficiently to remove a substantial amount of said first and/or second metals.

6. The method of Claim 1, wherein said polar solvent comprises deionized water.
7. The method of Claim 6, wherein said washing composition consists essentially of deionized water.
8. The method of Claim 1, wherein said polar composition comprises dilute acid.
9. The method of Claim 8, wherein said dilute acid has a pH of from 1 to less than 7.
10. The method of Claim 8, wherein said dilute acid is selected from the group consisting of dilute aqueous HCl, dilute aqueous HBr, and dilute aqueous HI.
11. The method of Claim 1, wherein said washing composition comprises a buffered acid.
12. The method of Claim 11, wherein said buffered acid comprises dilute aqueous acetic acid buffered with ammonium acetate.
13. The method of Claim 1, wherein said washing composition and said metal-contaminated Group IVA compound are present in a volume ratio of from 10:1 to 1:10.
14. The method of Claim 13, wherein said volume ratio is from 5:1 to 1:5.
15. The method of Claim 1, wherein said hydrogenated Group IVA compound comprises a cyclic Group IVA compound of the formula $(AH_z)_n$, where n is from 3 to 12, and each of the n instances of z is independently 1 or 2.
16. The method of Claim 15, wherein A is Si, n is from 5 to 8, and z is 2.

17. The method of Claim 2, wherein X is Cl.
18. The method of Claim 4, wherein d is 0.
19. The method of Claim 18, wherein M¹ comprises an alkali or alkaline earth metal, M² comprises a member selected from the group consisting of transition metals and Group IIIA elements, and a and b are each an integer of at least one.
20. The method of Claim 19, wherein M² comprises aluminum.
21. The method of Claim 4, wherein M² comprises a member selected from the group consisting of transition metals and Group IIIA elements, a is 0 or 1, d is at least 1, and each R is independently a member selected from the group consisting of an alkyl group, an alkoxy group, an alkoxyalkylene group, an alkoxyalkyleneoxy group, and a cyano group.
22. The method of Claim 21, wherein a is 0.
23. The method of Claim 22, wherein M² comprises aluminum, R is a C₁-C₆ alkyl group, and c and d are integers having a ratio of from 1:2 to 2:1.
24. The method of Claim 4, wherein M² comprises aluminum.
25. The method of Claim 24, wherein a is 1; M¹ comprises an alkali metal; each R is independently a C₁-C₆ alkyl group, a C₁-C₆ alkoxy group, a C₁-C₄ alkyl-C₁-C₆ alkylene group, a C₁-C₄ alkoxy-C₁-C₆ alkylene group or a C₁-C₄ alkoxy-C₁-C₆ alkyleneoxy group; and c and d are integers having a ratio of from 1:3 to 3:1.

26. The method of Claim 1, wherein after said washing step, said first and second metals are present in a concentration or amount of less than 100 parts per million Group IVA atoms in said hydrogenated Group IVA compound.
27. The method of Claim 26, wherein after said washing step, said first and second metals are present in an amount of less than 10 parts per million Group IVA atoms in said hydrogenated Group IVA compound.
28. The method of Claim 27, wherein after said washing step, said first and second metals are present in an amount of less than 1 part per million Group IVA atoms in said hydrogenated Group IVA compound.
29. The method of Claim 2, further comprising the step of reacting a compound of the formula A_xR_y with HX and a Lewis acid to form said compound of the formula A_xX_y , wherein X is a halogen and R is an alkyl group or an aryl group which may be substituted with alkyl, alkoxy, aryl, aralkyl, halogen and/or nitro groups.
30. The method of Claim 29, wherein R comprises a phenyl group.
31. The method of Claim 29, wherein said Lewis acid comprises a compound of the formula $M^3_pX_q$, where M^3 comprises a member selected from the group consisting of transition metals and Group IIIA elements, p is 1 or 2, and q is any integer up to the number of ligand binding sites available on the p instances of M^3 .
32. The method of Claim 31, wherein M^3 comprises Al, and X comprises Cl or Br.

33. The method of Claim 29, further comprising the step of reacting a seventh compound of the formula $A_uR_vX_w$ with a reducing agent to form said compound of the formula A_xR_y , wherein u is at least 1, v is at least 1, and w is any integer up to $(2u + 2 - v)$.
34. The method of Claim 33, wherein A is Si, u is 1, v is 1 or 2, and w is $(4 - v)$.
35. The method of Claim 33, wherein R comprises a phenyl group.
36. The method of Claim 33, wherein said reducing agent comprises an alkali metal.
37. The method of Claim 1, further comprising the step of drying said hydrogenated Group IVA compound.
38. The method of Claim 1, further comprising the step of distilling said hydrogenated Group IVA compound.
39. A composition, comprising:
 - a) a cyclic Group IVA compound of the formula $(AH_z)_n$, where n is from 3 to 12, each A is independently Si or Ge, and each of the n instances of z is independently 1 or 2; and
 - b) less than 100 parts of aluminum per million atoms of A in said Group IVA compound.
40. The composition of Claim 39, comprising less than 10 ppm of aluminum with respect to atoms of A in said Group IVA compound.
41. The composition of Claim 40, comprising less than 1 ppm with respect to atoms of A in said Group IVA compound.

42. The composition of Claim 39, wherein A is Si.
43. The composition of Claim 39, wherein z is 2.
44. The composition of Claim 39, wherein n is from 5 to 8.
45. The composition of Claim 39, wherein at least 85 mol% of said composition consists essentially of said cyclic Group IVA compound.
46. The composition of Claim 45, wherein at least 90 mol% of said composition consists essentially of said cyclic Group IVA compound.
47. The composition of Claim 46, wherein at least 95 mol% of said composition consists essentially of said cyclic Group IVA compound.
48. An ink for making a semiconductor film, comprising:
 - a) the composition of Claim 39; and
 - b) a solvent in which said composition is soluble.
49. The ink of Claim 48, wherein said cyclic Group IVA compound is present in said ink in a percentage by volume of from 0.1% to 50%.
50. The ink of Claim 48, wherein said solvent is aprotic.
51. The ink of Claim 48, wherein said solvent has a boiling point of less than 250 °C at atmospheric pressure.

52. The ink of Claim 52, wherein said solvent has a boiling point of less than 150 °C at atmospheric pressure.
53. The ink of Claim 48, consisting essentially of said composition and said solvent.
54. The ink of Claim 48, wherein each A in the formula (1) is Si.
55. The ink of Claim 48, wherein n is from 5 to 8.
56. A method of making a silicon-containing film, comprising the steps of:
 - a) depositing a layer of the ink of Claim 48 onto a substrate; and
 - b) curing said composition to form said silicon-containing film.
57. The method of Claim 56, wherein said silicon-containing film comprises a semiconductor film.
58. The method of Claim 56, wherein said depositing comprises spin coating, dip coating, spray coating, inkjetting, slit coating, meniscus coating or microspotting said ink on said substrate.
59. The method of Claim 56, wherein said curing step comprises drying said ink.
60. The method of Claim 56, wherein said curing step comprises oligomerizing, polymerizing and/or reducing solubility of said cyclic Group IVA compound.

61. The method of Claim 56, wherein said curing step comprises (i) heating said ink and/or composition to a temperature of at least about 100 °C, (ii) irradiating said ink and/or composition, or (iii) both (i) and (ii).
62. The method of Claim 61, wherein said curing step further comprises heating said composition to a temperature of at least about 200 °C to transform said composition into a polymeric and/or elemental material.
63. The method of Claim 61, wherein said curing comprises heating said composition to a temperature of at least about 300 °C in an inert or reducing atmosphere.
64. The method of Claim 56, further comprising patterning said semiconductor thin film.
65. A thin film structure comprising a cured, at least partially hydrogenated, at least partially amorphous Group IVA element, said Group IVA element consisting essentially of at least one of silicon and germanium, said thin film having less than 100 ppm of Group IIIA metal contaminants (other than intentionally added boron) relative to said Group IVA element.
66. The thin film structure of Claim 65, having less than 10 ppm of Group IIIA metal contaminants (other than intentionally added boron) relative to said Group IVA element.
67. The thin film structure of Claim 65, having less than 1 ppm of Group IIIA metal contaminants (other than intentionally added boron) relative to said Group IVA element.
68. The thin film structure of Claim 65, wherein said Group IVA element consists essentially of silicon.

69. The thin film structure of Claim 68, wherein said thin film structure consists essentially of silicon.
70. The thin film structure of Claim 68, wherein said thin film structure is semiconducting.
71. The thin film structure of Claim 65, wherein said Group IVA element further consists essentially of a dopant covalently bound to Group IVA atoms therein.
72. The thin film structure of Claim 71, wherein said dopant is selected from said group consisting of B, P and As.
73. The thin film structure of Claim 71, wherein said semiconducting thin film has a dopant concentration profile or gradient that is substantially uniform throughout a thickness of said thin film.